FOREST TREE PHYSIOLOGY RESEARCH AT THE OHIO AGRICULTURAL EXPERIMENT STATION

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The research in tree physiology at the Ohio Agricultural Experiment Station is aimed at establishing tree responses under controlled conditions.

The area of research we are pursuing includes the establishment of the symptoms of mineral element deficiency in several tree species and the effects of day-length, light quality, temperature and humidity in seed germination and seedling survival.

The two major areas presented in this paper deal with the effect of day-length on foliar abscission in several deciduous species and the effect of light quality on winter chlorosis in Scotch pine (Riga).

Effects of Day-length on Foliar Abscission in Several Species of Deciduous Trees

In a field experiment it was found that under total darkness the leaves of black locust abscissed by 15 days and those of red oak and white ash by 21 days. Under a 4-hour day-length there was no abscission in black locust; however, in the case of white ash and red oak at 56 days 70 percent and 90 percent of the leaves had abscissed, respectively. Longer photoperiods had no effect upon abscission in any of the above species.

The findings of the field experiment indicated that there was a differential reaction between species to day-length, and a more intensive study was set up under greenhouse conditions.

METHODS

On September 27, 1956, plants of the following species were potted and placed under greenhouse conditions: white ash, black locust, sugar maple, tuliptree, red oak, white oak, and redgum. The plants were initially maintained under a 15-hour day length, kept well watered, and observed daily as to changes in leaf color and leaf fall. On October 26, 1956, three plants of each species were placed in black cloth chambers on greenhouse benches under the following day-lengths: 0; 15 min.; 30 min.; 1 hr.; 2 hr.; 4 hr.; 15 hr.; and 24 hr. The 8-hour day-length period was omitted based upon field results in that no foliar abscission occurred.

The daily temperature ranged between 70 and 80 degrees F and the night temperature ranged between 56 and 70 degrees F.

RESULTS

The results are presented using averages and since the 15-min. and 1-hour photoperiodic reactions were intermediate between the 0 and ½-hour and ½-hour and 2-hour periods, they are omitted from the graphs.

Black locust.—Black locust responded to the narrowest range of day-length in that foliar abscission occurred during the 0 to 1-hour photoperiods. At 0 hours 100 percent leaf abscission was evident at 12 days and at 1 hour, 32 days. By 36 days only 14 percent of the leaves abscissed under the 2-hour period and 17 percent under the 4-hour period, while the plants continued to grow and no leaf fall occurred under the 15- and 24-hour period (fig. 1 and 2).

The leaflets abscissed prior to the petioles and under the 0 to 30 minute period

leaves remained green. Epinasty and anthocyanin pigmentation were evident in the leaves under the 1–hour photoperiod and yellowing of the top leaves in 2– and 4–hour periods (fig. 2).

Tuliptree and sugar maple.—Both the tuliptree and sugar maple responded in a very similar manner and only the data on the tuliptree are presented.

The range of reaction of foliar abscission was from 0– to 2–hour day-length, with 100 percent foliar abscission at 32 days under 0 hours; 100 percent abscission under ½ hour; 74 percent abscission under 2 hours; 34 percent abscission under 4 hours; and 8 percent abscission under 15 hours at 36 days (fig. 1 and 2).

The lower leaves were normally first to abscise and prior to abscission turned a bright yellow color.

The plants under the 15– and 24–hour period were a good green color and continued to produce new leaves.

Red oak.—Red oak was similar to the tuliptree in reaction, but the rate of abscission was earlier and higher. One hundred percent abscission occurred at 28 days under 0 hours day-length; 90 percent under ½ hour at 32 days; 86 percent under 2 hours at 36 days; 50 percent under 4 hours at 36 days; and 20 percent under 15 hours at 36 days (fig. 1 and 2).

The lower leaves were first to abscise, turning brown prior to abscission. In the top leaves a bright red color normally developed prior to abscission.

The plants in both the 15– and 24–hour periods remained green, but no new growth was noticeable.

Redgum, white ash, and white oak.—These three species reacted in a similar fashion as to time and rates of foliar abscission. The data on redgum are presented as being representative of the three.

The range of leaf abscission was the widest in this group, ranging from 0– to 4–hour day-length. One hundred percent abscission occurred earlier in time in white ash and white oak. The leaflets of white ash abscissed prior to the petioles, as in black locust.

In redgum, 100 percent abscission occurred at 32 days under 0 hours day-length; 82 percent under ½ hour at 36 days; 90 percent under 2 hours at 36 days; 80 percent under 4 hours at 32 days; and 8 percent under 15 hours at 32 days (fig. 1 and 2).

The lower leaves normally abscissed first. Some of the leaves abscissed green, but in general the leaves became a pale yellow color prior to abscission (fig. 2).

The plants under 15– and 24–hour day-length periods appeared to continue to grow in that new leaves were produced during the experiment.

CONCLUSIONS

Under the conditions of this experiment, it was generally found that the rate of foliar abscission and leaf coloration was directly correlated with day-length, the rate of abscission and leaf coloration being higher and earlier under the shorter photoperiods.

Although the pattern among some species was similar, each species responded to the varying day-length somewhat differently.

Black locust had the narrowest range of reaction with respect to day-length for leaf abscission, followed in order by the tuliptree group, red oak, with the broadest range in the redgum group.

SUMMARY

1. White ash, black locust, sugar maple, tuliptree, red oak, white oak, and redgum were maintained under greenhouse conditions and day-length periods of 0, ¼, ½, 1, 2, 4, 15 and 24 hours.

2. The temperature range was from 70 to 80 degrees F during the day and from 56 to 70 degrees F at night.

3. The plants responded in general to four ranges of day-length: 0 to 1 hour, black locust; 0 to 2 hours, tuliptree and sugar maple; 0 to 4 hours, red oak; and 0 to 4 hours, redgum, white ash, and white oak.

4. The leaflets abscissed prior to the petioles in the case of black locust and white ash.

5. Leaf coloration and rates of leaf abscission were directly correlated to day-length.

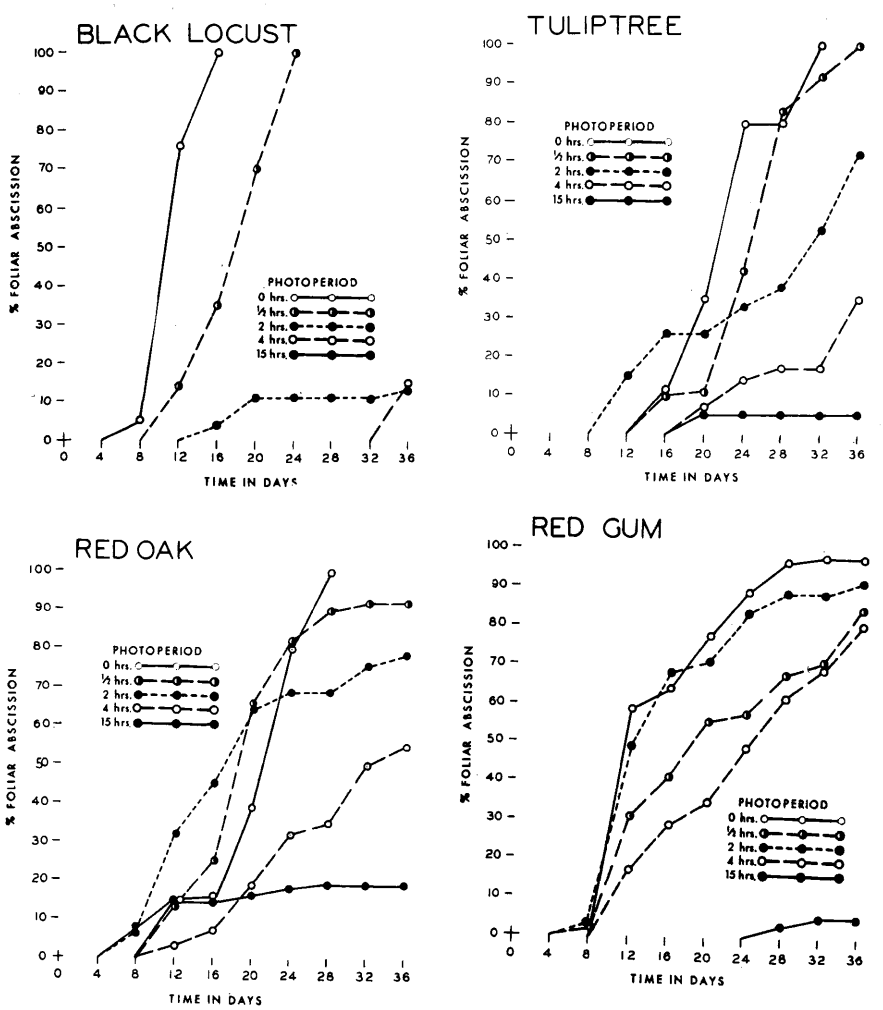

FIGURE 1. Average rates of foliar abscission in black locust, tuliptree, red oak and redgum.

The Effects of Light Quality on Winter Chlorosis in Scotch Pine (Riga)

It is known that the color of the needles during the winter months varies from a blue green to a brilliant golden yellow in Scotch pine, depending upon the origin or location of the source of seed. The problem of such winter chlorosis

has been recently reappraised due to the interest in the use of Scotch pine (Riga) in Christmas tree production.

The Riga strain of Scotch pine turns a golden yellow during late fall and early winter and was selected as the experimental plant in attempts to correct or alleviate the winter chlorotic condition.

Field applications of fertilizers in the form of single salt solutions of nitrogen, phosophorus, potassium, calcium, magnesium, and iron at the rates of 0, 100, 500, and 1000 pounds per acre did not appear to have any effect upon winter chlorosis after two years.

Spectrographic analyses of the root, stem, and leaves of a single winter collection of a yellow tree and a green tree did not indicate any appreciable differences in mineral content. Many of the ions were of the same relative concentrations, and in some instances were higher in the yellow plant than in the green plant.

METHODS

A block of Scotch pine (Riga) planted in 1952 was selected for experimentation with the effects of the quality of light upon winter chlorosis. The trees were a good green color on September 15; winter chlorosis was evident on October 15, and pronounced by November 15. However, the intense golden yellow was not apparent until the last two weeks of December.

Trees were selected at random in the planting and were covered with either perforate or non-perforate polyethylene bags of the following colors: transparent, black, red, or blue. Neither the percent of transmission nor the actual wave length transmitted have been evaluated.

The time of covering was September 15, October 15, and November 15, 1956. Each treatment was a single tree replicated twice at the above dates. The plastic bags were removed December 15, 1956, except the September series which was removed November 15, 1956.

Visual comparisons were made of the effects of the colored polyethylene bags at two-week intervals after application. The final evaluation was made four months after the beginning of the experiment, on January 15, 1957.

RESULTS

There were no apparent differences between the tree response to the perforate or non-perforate polyethylene bags.

September 15 treatment.—The trees covered with the transparent and blue polyethylene bags became yellow as did the uncovered trees; those covered with black died due to the probable high internal temperatures; the trees under red remained a good green color and were decidedly bluer-green than the greenest uncovered trees in the area.

October 15 treatment.—The trees under transparent, black, and blue polyethylene bags became chlorotic, while those plants under red did not become more chlorotic, but seemed to retain the color at the time of application.

November 15 treatment.—The trees responded in the same similar manner as the October 15 application.

CONCLUSIONS

Winter chlorosis of the needles apparently was not affected by the covering of Scotch pine (Riga) trees with black, transparent, or blue polyethylene bags. However, in the case of the red bags, the needles on the trees appeared to retain their green color. Although red colored bags prevented the further development of winter chlorosis, it did not apparently result in the correction or reversal from a yellow condition to a green condition of the needles.

Further work is being prepared to observe whether this is a phenomenon of reduced light intensity or light quality.

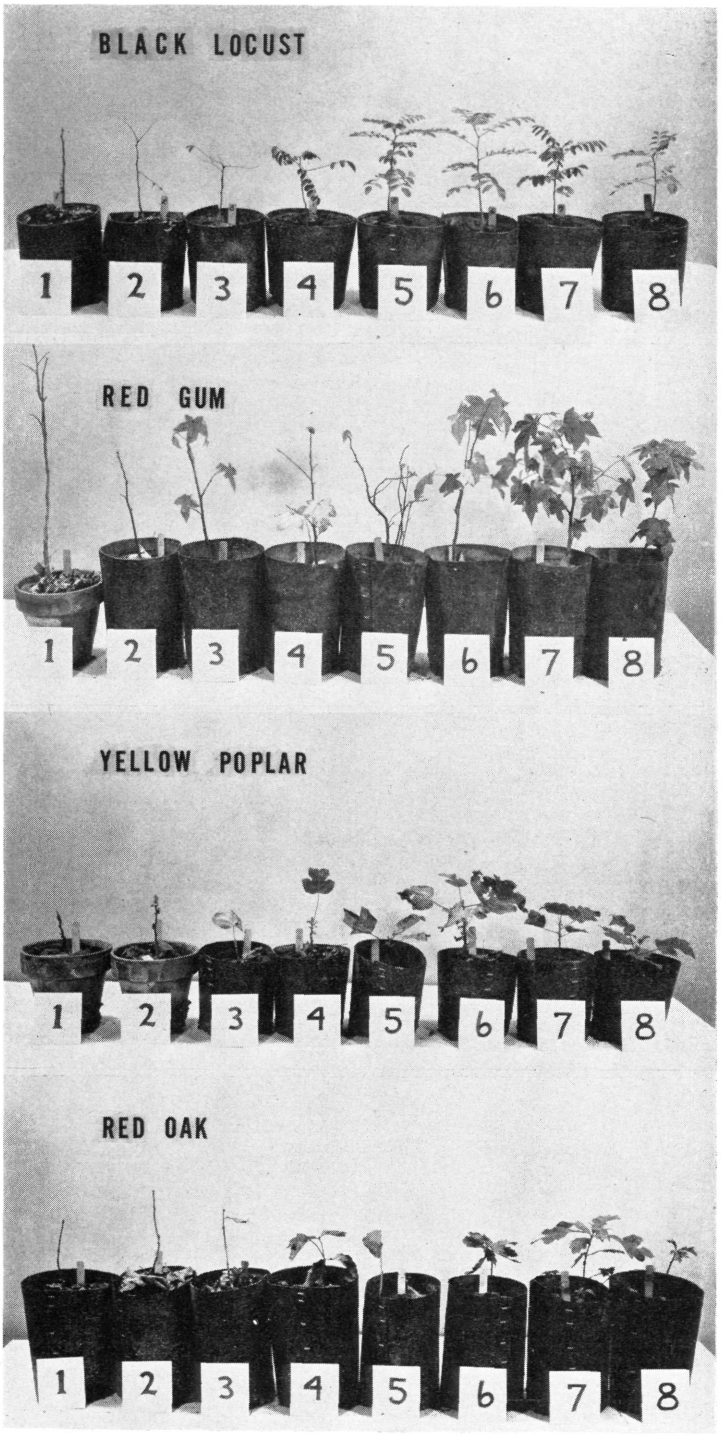

FIGURE 2. Appearance of the average plants at the termination of the experiment. Photoperiods: **1**. 0; **2**. ¼–hr.; **3**. ½–hr.; **4**. 1–hr.; **5**. 2–hr.; **6**. 4–hr.; **7**. 15–hr.; and **8**. 24–hr.

SUMMARY

1. Scotch pine (Riga) trees planted in 1952 were covered with transparent, black, blue, or red polyethylene bags to observe the effects of light quality on winter chlorosis.

2. Transparent, black, and blue polyethylene bags had no apparent effect upon the prevention of winter chlorosis.

3. Red colored polyethylene bags prevented the onset and further development of winter chlorosis.

4. Further work is planned to test the effect of light intensity as opposed to light quality.

DISCUSSION

DENNIS RICHARDSON (*University of Aberdeen, Scotland*): In your experiment demonstrating that chlorosis in Scots pine trees can be arrested by covering them with red plastic, is it possible to separate the effect of red light *per se* and that if a reduction in light intensity is due to the cover? (Observation of Dr. Richardson in the experiment relating abscission to very short [less than 4 hours] photoperiods). It would be useful as a follow-up to this very interesting experiment to attempt to separate what have been described as, respectively, photo-energetic and photo-stimulative reaction, *i.e.*, in this case, to find out whether leaf abscission results from a reduction in the duration of exposure to light (or in truly "photoperiodic" responses). This could be done by giving the same total amount of light energy spread over periods of, say, 4 hours and 15 hours.

JOHN HACSKAYLO: At the present time, no; however, we plan to run a more extensive experiment this fall and evaluate the effects of shading as well as color by using burlap.

HENRY G. GERHOLD (*Penn. State University*): What wave lengths of light are transmitted by the red and blue plastics which you used?

JOHN HACSKAYLO: At present we do not know, but plan to have the transmission of light quality analyzed.

HENRY G. GERHOLD: Did you try other plastics besides polyethylene?

JOHN HACSKAYLO: No.

HENRY G. GERHOLD: Between what dates were the trees shaded, and how long thereafter did they retain their green color (trees covered by red plastic)?

JOHN HACSKAYLO: The trees were covered with the polyethylene bags on September 15, October 15, and November 15, 1956. All of the bags were removed on December 15, 1956 with the exception of the September 15 series which were removed on November 15, 1956.